EXOTIC PLANT REDUCTION IN HAWAII VOLCANOES NATIONAL PARK: AN UPDATE

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INTRODUCTION

Exotic plant problems are probably worse in Hawaii than in any other place in the world. In much of our island state, exotic species vastly outnumber natives, and in Hawaii Volcanoes National Park, about 400 of the 600-odd species listed by Fosberg are introduced.[1] Johnny Appleseedism, promoted by post-Polynesian colonizers, depredations by introduced mammals, commercial agriculture and livestock raising, and indifference by private and public land managers are the primary causes of the problem.

In a presentation before this conference in June 1980, I described a systematic approach to exotic plant management which would guide our efforts during the next several years. This approach consisted of classifying exotic species according to their disruptive potential, on the one hand, and according to probability for successful control on the other hand. The most disruptive or potentially disruptive exotic plant species were listed in priority order--about 10% of the exotic plant list for the park. These were further classified according to extent of distribution, and then judged according to the likelihood of our ability to control them. Generally, aggressive species which are still localized in distribution receive greater consideration for control work than do unaggressive species or aggressive species which are now widely distributed. Control work is generally not undertaken in areas where pigs, goats, people, or other disruptive forces would neutralize our efforts, and is generally applied first in areas of greatest ecological importance.

Work projects are defined with the aid of large-scale internally produced distribution maps; work cycles are scheduled, method of treatment is determined, and the control is evaluated by a simple system of repeatable workings of control units. The system which began about 2½ years ago has demonstrated some remarkable success, some surprises, and some disappointments.

MATERIALS AND METHODS

Fountain grass (Pennisetum setaceum), koa-haole (Leucaena leucocephala), firetree (Myrica faya), kahili ginger (Hedychium Gardnerianum), and kikuyu grass (Pennisetum clandestinum) have received most of our attention these past 2½ years. Work has also been carried out opportunistically on localized populations of Christmasberry (Schinus terebinthifolius), silky oak (Grevillea robusta), black wattle (Acacia decurrens), ironwood (Casuarina equisetifolia), and others. Considerable concern has been raised over the rapid spread of banana poka (Passiflora molissima).

1. Fountain grass, introduced to western Hawaii near Hualalai around 1910 as an ornamental plant, quickly became established and now occupies thousands of hectares on the western slopes of Mauna Kea, Hualalai, Mauna Loa, and parts of the Kohala Mountains. It has become established in parts of the Ka'u and Puna Districts of southern Hawaii, including sections of the national park, where it is nearly under control after about three years of effort. This extraordinarily successful bunchgrass occupies disturbed or recently formed sites from sea level to 3,000 m elevation. In the park it readily colonizes lava flows, arid kipukas, and road shoulders. The main infestation center is a 1,500 ha area in the southwestern portion of the park, which is characterized by recent a'a and pahoehoe lava flows and sand dunes interspersed with sparsely wooded kipukas. Once the prime territory of feral goats, which kept all vegetation well-cropped, this area now abounds with exotic grasses and occasional natives, such as pili (Heteropogon contortus), 'ōhai (Sesbania tomentosa), awikiwiki (Canavalia kauensis), a'ali'i (Dodonaea eriocarpa), pukiawe (Styphelia tameiameiae), 'ohi'a (Metrosideros collina), and others. If left unchecked, fountain grass would occupy lava flows, dominate kipukas, and would surely spread well beyond its present confinement. This species' aggressive behavior, its flammability and vigorous rejuvenation following fire, and its currently localized distribution qualify it for all-out control effort.

We have developed two approaches for control: (a) frequent periodic surveillance and eradication along road and trail corridors, the species' primary route of invasion into the park (During the past two years, we have uprooted more than 100 plants from at least 18 sites along the Highway #11

and Chain of Craters Road corridors.); (b) systematic grid-search of the 1,500 ha infestation area in the Kamo'oali'i area of the southwestern part of the park. The area is subdivided into six blocks of about 20-400 ha. Blocks are carefully combed or scouted by teams of four to eight workers who uproot plants as they are spotted. This method results in a better-than-95% eradication rate. Seeds of flowering plants are collected and kept in plastic bags, to be burned later in evening campfires.

During initial work in 1979, the effort focused on about 20 ha of large, flowering bunches which could not be uprooted. Plants were treated with the herbicide Roundup in 2% dilution with water, which proved quite effective. After the first year of treatment, there were no unmovable bunches of fountain grass left, so treatment by herbicide became unnecessary, since nearly all plants could now be quite easily uprooted. By early 1980 it became obvious that plants had dispersed widely, and the control area was extended to include an area 40 times larger than the original treatment area. Rather than dense stands of fountain grass, the clumps are now sparse and relatively unproductive if treated every 12-16 weeks (See Table I).

2. Koa-haole, also called ekoa, was introduced to Hawaii as fodder for cattle. It is found on all islands, and in some places dominates vast areas. In the national park, it is found mostly along trails or in former pasturing stopovers in the Keauhou-Halape-Ainahou trail and fence-line system. It is also found on Pu'u Kaone, in one place along the Kalapana Trail, and occasionally as individuals in other parts of the backcountry. A prolific and durable legume, koa-haole thrives in the more arid portions of the park. The plant produces pods containing very hard-coated and presumably long-lived seeds which do not disperse widely unless carried by people or animals. Consequently, in the absence of dispersing agents, stands tend to remain stationary but persistent.

Several years ago mature, dense stands were sprayed with the herbicide Kuron, which is no longer permitted in national parks. Some control was achieved by this method. More recently, we cut stems within 30 cm of ground level and painted stem tops with the herbicide Tordon 22K liquid. This proved only partially successful, as some individuals resprouted. Our efforts shifted to placing a dozen or so Tordon 10K pellets at the base of each plant,

or scattering handfuls of pellets in dense stands. Tordon 10K was far more effective and less time-consuming, although we have not solved the problem of seedling establishment, and are disturbed by the ability of some plants to survive Tordon 10K application. Although stronger dosages and more frequent application may result in greater kill, we are very reluctant to continue using Tordon. We will experiment with less persistent herbicides, such as Garlon (a Dow product), and hope to be able to report more encouraging results (See Table II).

3. Firetree was introduced to Hawaii in the early 1900's from the Canary, Azores, and Madeira Islands of the northern Atlantic. The species now occupies a broad area east of the park in formerly closed 'ohi'a forest opened up by suburban development, and an area within the park from the closed 'ohi'a forest, westward to the arid margins of 'ohi'a woodland. It ranges from about 400 m to 1,300 m elevation and currently occupies about 6,500 ha of park land. It is spreading and intensifying at an alarming rate, bringing nitrogen fixation and flammability problems with it. Seeds are encased in a hard, spherical capsule about 2-3 mm in diameter. They are surrounded by mulberry-like fruit which ripen in July-September. The primary dispersing agent is thought to be birds, such as mynah or dove.

Our treatment of firetree is confined to a 500 ha section of the park from the closed 'ohi'a forest of the east boundary to the Ka'u Desert, and from Kilauea Caldera to Kipuka Puaulu. The western and northern limits of this control area also define the ecological limits of the species. We are unfortunately compelled by limits of funding and personnel to write off control of firetree in the remaining 90% of its range in the park. A biological control is urgently needed for this species.

Initial control efforts 1½ years ago required intensive and time-consuming eradication of mature flowering trees. There were hundreds of them in the area, and frequently they were 4 m or more tall. Firetrees sprout vigorously when cut, so it is necessary to either uproot or poison them. Plants taller than 1.5 m are normally too well-rooted for most people to safely uproot. A method of introducing herbicide directly to the vascular tissue of the plant was developed by Gardner and Kageler[2] which proved effective in controlling large numbers of mature plants. This enabled us to

eliminate the seed source inside our control unit within the first several months, and thus provided a quite controllable and unproductive population in a relatively short time. The 500 ha control unit is subdivided into nine sub-units. Each sub-unit is quickly and systematically covered by persons on foot (and lately in some areas on horseback), who uproot seedlings as they are spotted. Eradication of about 85% of plants less than 1 m tall and 99% of plants less than 2 m tall is achieved by this method. Numbers of plants and percentage of flowering plants have been substantially reduced in the control unit. The amount of time required to maintain control is less than 30% of the time required to do initial eradication. It is believed that if the seed source in Volcano Village and the Golf and Country Club residential area could be eliminated, our control efforts could be reduced further (See Table III).

4. Kahili ginger, an introduction from southeastern Asia within the past 30 years, is an ornamental escapee. One of three species of ginger in this area, it has become well-established in the community of Volcano, in the Volcano House hotel and employee residential areas, and in the closed 'ohi'a forest for several kilometers around. Ginger is a persistent, shade-tolerant herb which produces a quite magnificent inflorescence during the summer months. The inflorescence resembles the kahili staffs used in royal court ceremonies, hence its common name. Seeds are contained in a hard, lens-like orange, glabrous casing about 2-3 mm in diameter, and is presumably dispersed by birds. Seedlings are compounded by prolific growth from roots which contribute greatly to stand intensification. Plant clusters present an unusually dense mass of roots and foliage, and quickly usurp space in the forest understory, especially in areas disturbed by pigs or humans.

Our work in eradicating ginger has only just begun. We have had some success uprooting it where the stand is sparse and invasion is recent. In dense, well-established stands, Tordon 10K pellets kill ginger effectively, but unfortunately have killed surrounding plants also, including mature 'ohi'a trees. Experiments using Amitrol, a systemic liquid herbicide, indicate potential for success, but this herbicide is not approved for use in national parks. We are hoping experiments with the approved chemical Garlon will indicate control potential.

To date, ginger has been controlled in Kipuka Puaulu, Thurston Lava Tube trailhead area, and in a 20 ha section of 'ohi'a forest between the Research Center and Waldron Ledge. Control in other areas must await a suitable herbicide or biological control.

5. Kikuyu grass, introduced for livestock pasturage from East Africa, abounds in mid- and high-elevation ranchlands all over the island. It covers vast areas of the Keauhou and Kapapala Ranches, and agricultural lots along Wright Road adjacent to the park. In the national park kikuyu grass is found mostly along road margins from Kipuka Ki to Puhimau Crater. In parts of Kipuka Ki, the former Ainahou Ranch, and the headquarters-residential-Research Center areas, there are broader expanses of this grass. Kikuyu grass is most aggressive in openings, such as pastures and road corridors, but it also can spread into the fringes of closed forest where it exploits natural openings. The grass has a notorious tendency to climb, and thus can cover fences, roadside shrubs, etc. It so completely covers the ground that native species (and most exotics) are suppressed. Ultimately, road corridors and pasture areas would thus encroach upon the forest.

Kikuyu grass in the park is clearly a controllable species. In experiments conducted by Gardner, it was learned that a 1½% mixture of Roundup herbicide in water, broadcast-sprayed on kikuyu grass stands, which often include remnant native shrubs and herbs, will tend to kill only kikuyu grass. Evidently native species are able to tolerate this mild application of herbicide. This is a fortuitous discovery, for it enhances the possibility for control of kikuyu grass without seriously affecting native species which are closely associated with it.

We have so far treated about 5 km of roadsides and about 2 ha of open field grass near the Research Center--about 30% of the total area requiring treatment. Results are encouraging, despite some evidence that kikuyu grass will be at least partially replaced by other exotic grasses.

6. Banana poka, perhaps the most serious threat to the survival of the koa-'ohi'a forest, is an exotic vine which defies chemical or mechanical treatment. Introduced to Hawaii from the northern Andes Mountains of South America, banana poka became established in four main centers in Hawaii, including the Ola'a Tract section of the park. The plant arrived here during the early 1950's, when it was planted in a homesite garden on Wright Road and subsequently

escaped. It presently is found in most parts of the non-contiguous 3,862 ha Ola'a Tract section of the park, where it is still spreading and greatly intensifying.

Seeds are contained within a very hard lens-like casing, which is surrounded by a fleshy, aromatic, banana-shaped fruit which falls to the ground when ripe. The fruit is readily scavenged by feral pigs, who pass seeds several hours later and, presumably, some distance from the point of ingestion. Birds are also thought to disperse banana poka seeds.

In its native Andes habitat, banana poka is a relatively minor constituent of the forest, unlike Hawaii, where the plant is exceedingly aggressive. Butterflies of the genus Heliconius are reported to severely limit the spread and density of banana poka in South America, and it is possible that this insect would provide some constraints on banana poka in Hawaii. Insect predators, perhaps in combination with pathogenic agents, offer the only realistic solution to banana poka control. State Department of Agriculture concerns for adverse impact of biocontrol on the small commercial passion fruit industry must be overridden by concerns for the survival of native koa-'ohi'a forest communities.

We have attempted no control in the park, as we are aware of futile attempts elsewhere to uproot or poison this plant. We fully support biological research, and are formulating an interagency agreement with state and other federal agencies to jointly develop a control method for banana poka. Under this agreement, it is proposed that a section of the greenhouse facility at the Research Center will be converted to an insect quarantine laboratory.

RESULTS AND DISCUSSION

The effort needed to control exotic plants is easily underrated, as reference to Tables I, II, and III below will illustrate. Limits of personnel and funds require very careful attention to work priorities and restraint in undertaking new work projects. Hawaii Volcanoes National Park has only five workers who are assigned to exotic plant and feral animal control programs; these workers earn about $20,000 per year, on the average, and their equipment support costs amount to about $30,000 per year. Exotic plant control commands about 70% of this time and money.

The following tables summarize about half of the work accomplished by this team of workers in one year. The other half of work accomplishment is accounted for mostly in unsummarized exotic plant control and feral animal control projects.

Since the data in Tables I - III has been compiled only during the past couple of years, it is premature to announce trends. However, we are encouraged by the reduction of firetree and fountaingrass densities and reproductive potential, especially during the past year. Despite the erratic performance of koa-haole generalized data, we have seen substantial reduction of plants in several of the 38 blocks. As work areas and treatment intervals stabilize during the next couple of years, we expect to produce more demonstrative results in control of these target exotic species.

TABLE I. Fountain grass control*

Date	1,500 ha Kamo'oali'i	120 ha Kue'e	2 ha Kaone	< 1 ha Pit Craters	25 ha Holei Pali	1 ha Roadsides
1-3/80						66 (12%) ¼ MD
4-6/80	6,925 (3%) 23 MD		16 (12%) NA			
7-9/80						
10-12/80	4,139 (3%) NA					
1-3/81	1,827 (15%) 27 MD					
4-6/81	4,995 (10%) 14 MD					33 (12%) ¼ MD
7-9/81	3,245 (2%) 32 MD					10 (3%) ¼ MD
10-12/81	2,382 (6%) 28 MD			221 (6%) 3 MD		
1-3/82	24,655 (3%) 98 MD	80 (38%) 2 MD			10 (70%) ¼ MD	1,872 (3%) 2 MD
4-6/82	7,972 (4%) 17 MD	25 (4%) 1 MD			353 (8%) 3 MD	25 (4%) ¼ MD

*In each column the first figure indicates the actual number of plants killed; the second figure, in parentheses, indicates the percentage of flowering plants; the third figure indicates the number of worker-days it took to accomplish the work.

During the period represented by this data summary, the area of the Kamo'oali'i unit increased about forty-fold. We believe the area and work interval stabilized during the first quarter of 1982, and will judge results of our efforts from that period.

TABLE II. Koa-haole control: Halape-Keauhou coastal area (38 blocks--10 ha)

Date	Plants killed	% flowering	Worker days	Comment
Feb. 1980	2,369	19	20	Block 4 (.5 ha)
Mar. "	6,500	23	16	Block 14 (1.5 ha)
Apr. "	2,300	26	12	Blocks 1, 2, 14
June "	280	0	2	11 Blocks
Sept. "	3,226	45	12	13 "
May 1981	1,851	25	6	29 "
Jul. "	159	45	6	19 "
Oct. "	255	0	4	27 "
Feb. 1982	1,886	50	12	3 "
Apr. "	950	<1	6	10 "

Blocks which were not worked since May, 1981 did not have koa-haole growing in them at the time of working. Some of these blocks indicated rejuvenation later and required more working.

TABLE III. Firetree control (500 ha).

Date	Plants killed	% flowering	Worker days	Comment
Jun. 1980	471	42	NA	Block 4 (70 ha)
Aug. "	240	29	NA	Block 9 (50 ha)
Nov. "	1,694	7	NA	Blocks 1-4 (23 ha)
Feb. 1981	2,109	0.5	18	" 5, 6, 8, 10 (140 ha)
Aug. "	8,989	9	146	" 1-8 (380 ha)
Nov. "	2,199	20	67	" 4, 9 (125 ha)
Jan 1982	3,681	1	59	" 1-8, 10 (450 ha)
Mar. "	2,159	0.4	80	" 1-10 (500 ha)

MANAGEMENT RECOMMENDATIONS

The major emphasis in Resources Management in Hawaii Volcanoes National Park is removal of exotic influences from native ecosystems. We are assuming that this strategy, as opposed to a strategy of native plant propagation and native animal husbandry, will eventually neutralize the impact of introduced plants and animals and allow natural processes to once again determine the course of evolution in the park. Considering the overwhelming character of exotic plant and feral animal influences on island ecosystems, it is very important to direct management efforts at solvable, lasting, and ecologically significant problems. This is especially so during current times of fiscal restraint.

Exotic plant control efforts in the park have not historically been carried out with the benefit of applied research. It is the intent of current managers to subject our plant management work to scientific scrutiny and advice. The result will be a more ecologically conceived program.

LITERATURE CITED

1. Fosberg, F.R. 1975. Revised checklist of vascular plants of Hawaii Volcanoes National Park (technical report no. 5). Honolulu: C.P.S.U., University of Hawaii. 19 pp.
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